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Effect of Surface on Residual Activity of Selected Compounds[1]

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ABSTRACT

Twenty-two compounds were tested as residual deposits against *Musca domestica* L. and *Blattella germanica* (L.) on painted and unpainted galvanized metal, tempered masonite, and asphalt tile surfaces. The applications were made at 50, 100, and 200 mg per square foot except for ronnel and dimethoate. Dimethoate was the most effective compound against *M. domestica* when all 4 surfaces are considered. On the individual surfaces dimethoate was most effective on painted metal, Hercules 9699 [*o*-(2-propynyloxy) phenyl methylcarbamate] on unpainted metal and tempered masonite and Bayer 37344 [4-(methylthio)-3,5 xylyl methylcarbamate] on asphalt tile. Hercules 9699 was the most effective toxicant against *B. germanica* on all 4 surfaces. On the individual surfaces Baygon[2] (*o*-isopropoxyphenyl methylcarbamate), was most effective on painted metal. Hercules 9699 on unpainted metal, Bayer 46676 (*O*-ethyl *O*-[2-(ethylthio)-6-methyl-4-pyrimidinyl] ethylphosphonothioate) on tempered masonite and Hercules 9699 on asphalt tile.

Control efforts for the house fly, *Musca domestica* L., and for the German cockroach, *Blattella germanica* (L.), rely upon residual treatment of the infested areas as one of the principal means of combating these pests. Since the advent of widespread resistance to the chlorinated hydrocarbon compounds in populations of both species, various organophosphorus compounds have been used. However, these compounds, with the exception of dimethoate, generally lack the residual characteristics of DDT, dieldrin, and related chemicals. Variation in insect kill with the same toxicant on different surfaces has been reported by various workers (Schoof et al. 1962, Mathis and Schoof 1963). This study reports on the effect of treated surfaces on the residual activity of 22 toxicants, representing 4 classes of compounds, against *M. domestica* and *B. germanica*.

METHODS.—*M. domestica*.—The equipment and technique described by Jakob and Schoof (1963) with minor modifications were used in these tests. The treated panels (3×12 in.) were fitted into a wooden framework and held in place by a wire spring to form a rectangular chamber, the total surface area of which was 1 ft². Each opening and untreated end of the framework was fitted with a removable metal collar-flange. Between each testing operation these pieces were removed and cleaned to minimize the possibility of cumulative contamination. Since the chamber was used in a vertical position, the "knocked down" house flies fell onto an untreated surface. The 4 types of surface materials used were metal, painted metal, masonite, and asphalt tile.[3] The experimental compounds are listed in Table 1.[4]

Three-day-old insectary-reared adult house flies (sus-

[1] Accepted for publication February 11, 1966.

[3] Painted according to Navy instructions with a coat of zinc chromate primer formulae 61 and 2 coats semigloss white; each coat 0.001 in. thick; panels aged 1 month before use.

[4] Use of trade names is for identification purposes only and does not constitute endorsement by the Public Health Service.

Table 1.—Chemical composition of tested compounds which have no approved common names.[a]

Designation	Chemical Composition
Baygon[b]	*o*-isopropoxyphenyl methylcarbamate
B-30237	*O*-methyl *O*-[*p*-(methylthio) phenyl] methyl phosphonothioate
B-34098	*O*-[4-(methylthio) *m*-tolyl]dimethylphosphorothioate
B-37341	4-(methylthio)-3,5 xylyl methylcarbamate
B-41831	*O,O*-diethyl *O*-4-nitro-*m*-tolyl phosphonothioate
B-16676	*O*-ethyl *O*-[2-(ethylthio) 6-methyl-4-pyrimidinyl] ethylphosphonothioate
CP-40298	*O*-2-chloroallyl *O*-(*alpha*, *alpha*, *alpha*-trifluoro-4-nitro-*m*-tolyl) methylphosphonothioate
Her 7816D	*O,O* diethyl phosphorodithioate *S*-ester with 3-(mercaptomethyl)-2-benzothiazolinone
Her 9699	*o*-(2-propynyloxy) phenyl methylcarbamate
HRS-1422	3,5 diisopropylphenyl methylcarbamate
N-2101	*O*-(2-chloro-4-nitrophenyl) *O*-isopropyl ethylphosphonothioate
N-2788	*O*-ethyl *S*-*p*-tolyl ethylphosphonodithioate
N-2789	*O*-ethyl *S*-*o*-tolyl ethylphosphonodithioate
N-2790	*O*-ethyl-*S*-phenyl ethylphosphonodithioate
SD-7438	benzylidene methyl phosphorodithioate
UC-10854	*m*-isopropylphenyl methylcarbamate

[a] Abbreviations for company designations are: B = Bayer, CP = Monsanto Chemical Co., Her = Hercules Powder Co., HRS = Hooker Chemical Co., S = Stauffer Chemical Co., SD = Shell Chemical Co., UC = Union Carbide Chemicals Co.

reptible unless indicated otherwise) were used in the tests. Eighty to 120 adults (mixed sexes) were removed from the emergence cage to a plastic cylinder cage, then transferred by compressed air to the exposure chamber. After 30 min exposure, the flies were blown by compressed air into a screen-wire holding cage and held with food at 80°F and 70% rh for the 24-hr mortality count. Only the female mortality was considered. Each concentration was replicated 3 times on each of the 4 surfaces, and untreated checks were used in each test.

B. germanica.—The same panels employed in the house fly tests were used for the cockroach experiments. Twenty to 25 young adult cockroaches (mixed sexes) of the Ft. Rucker[1] strain were placed in a talc-coated container (diam 3½ in., height 2½ in.) with ⅛-in. holes drilled in the bottom to allow air exchange. The containers were inverted on the panels, held together in a horizontal position (Fig. 1), and the test insects confined for 3 hr. On removal they were placed in a pint jar, provided with a laboratory chow pellet and 10% honey water, and held at 80°F and 70% rh for the 24-hr mortality count. Only the female mortality was considered in the results. Each concentration was replicated 3 times on each of the 4 surfaces. Untreated checks were used in each test as well as a diazinon standard. The compounds tested are listed according to classes in Table 2. Emulsion formulations (1:4 ratio of concentrate to H₂O) of the candidate compounds were used. The oil phase for all toxicants was 2% Triton X-155 in xylene. Each formulation was sprayed (40 lb/in²) onto 4 panels of each surface type at a rate of 1 ml/ft² by passing the panels beneath an 8001 Teejet nozzle (15 in.[2] above the panels). During the spraying operation the formulations were agitated constantly by a magnetic stirrer. The concentration was varied to give 3 dosages (50, 100, and 200 mg/ft²) unless otherwise indicated. After drying overnight, the residues were tested at 1-day and at 1-week intervals until they failed.[3] Between tests the panels were stored in cubicles maintained at approximately 80°F and under negative air pressure.

[1] Resistant to chlordane, dieldrin, and lindane.

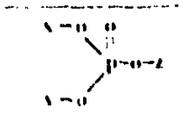
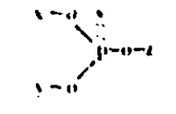
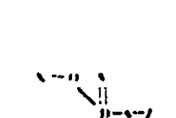
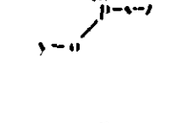
RESULTS.—*M. domestica.*—Data for the 21 compounds against *M. domestica* (Table 3) showed that the 6 phosphorodithioate compounds were relatively ineffective at all dosage rates on the 4 test surfaces, except for dimethoate which gave 11, 26, and 20 weeks of satisfactory kills on painted and unpainted metal and masonite, respectively.

Of the 9 phosphorothionate compounds tested, B-30237 and B-34098 gave the longest residual action on the 4 test surfaces, with the latter being outstanding. B-34098 gave 9, 27, 17, and 31 weeks of satisfactory kills on painted metal, unpainted metal, masonite, and tile, respectively, at 200 mg/ft² although at that dosage B-30237 was markedly superior to B-34098 on 1 surface (painted metal). Fenthion gave good results on unpainted metal at 50, 100, or 200 mg/ft² but was poor on the other 3 surfaces. Residues

[3] Mortalities at or below 70% (after exposure of 30 min for flies and 3 hr for cockroaches) are considered unsatisfactory.

FIG. 1.—Cockroaches confined to treated surfaces under talc-coated containers.

Table 2.—List of compounds according to classes tested against both *M. domestica* and *B. germanica*.

Class	Compounds	Type formula
phosphate	dichlorvos naled	
phosphorothioate	Bayer 30237, 34098, 41831, 16676 CP 40298 diazinon fenthion tormel Stauffer N-2101	
phosphorodithioate	dimethoate 41-7816D SD 7438 Stauffer N-2788 N-2789 N-2790	
carbamate	Baygon B-37341 41-9699 HRS-1422 UC-10854	

of Stauffer N-2101 gave kills of 11 and 21 weeks on masonite and unpainted metal but were ineffective on the other 2 surfaces.

The 2 compounds of the phosphate class (Table 3), naled and dichlorvos, were ineffective on the unpainted metal and showed limited residual action on the other surface.

Of the carbamate compounds, H-9699, B-37341, and HRS-1422 at 200 mg/ft² gave effective kills for the longest periods on 3 of the 4 surfaces (Table 3). B-37341 and HRS-1422 were ineffective on masonite, while H-9699 displayed its shortest persistence on painted metal. B-37341 and H-9699 were the most effective of all the compounds tested on unpainted metal and tile.

B. germanica.—Against the German cockroach, all compounds of the phosphorodithioate or the phosphate class gave 2 weeks or less of effective kills at all dosages with the exception of H-7816D which gave 11 weeks of satisfactory results at 200 mg/ft² on unpainted metal, and diazinon which gave 4 and 8 weeks of effective kills at 100 and 200 mg/ft² on tile (Table 4).

Of the phosphorothionate compounds, only B-30237 at 200 mg/ft² gave more than 2 weeks (7 weeks) effective kills when applied to painted galvanized metal. On unpainted metal and masonite B-34098, B-16676, and Stauffer N-2101 were the most effective toxicants. On asphalt tile, only B-34098 at 200 mg/ft² was effective for more than 2 weeks (5 weeks).

Of the 6 carbamate compounds tested, Baygon, H-9699, and UC-10854 produced satisfactory results for more than 3 weeks on any surface. H-9699 was far superior to Baygon and UC-10854 on unpainted metal, masonite, and tile. On painted metal Baygon and H-9699 gave equivalent results that were better than those obtained with UC-10854.

DISCUSSION.—The data for the 22 compounds against *M. domestica* and *B. germanica* not only indicate considerable variation between and within the 4 classes of compounds involved but also emphasize that efficacy

Table 3.—Number of weeks of effective kills of female *M. domestica*[a] exposed for 30 min to emulsion residues of various compounds on 4 surfaces.

Class	Compounds	Mg/ft²	Galvanized metal		Masonite	Tile
			Painted	Unpainted	Unpainted	Unpainted
phosphate	dichlorvos	50	1	0	3	1
		100	1	0	4	1
		200	2	2	4	4
	naled	50	5	0	5	0
		100	5	0	5	1
		200	9	0	9	1
phosphoro-thioate	B-30237[b]	50	1	1	1	1
		100	5	5	5	5
		200	33	9	5	31
	B-34098	50	1	9	3	3
		100	3	12	12	12
		200	9	27	17	31
	B-41831	50	0	1	1	0
		100	1	1	1	1
		200	1	9	3	3
	B-16676[b]	50	0	1	1	0
		100	1	1	1	0
		200	1	10	10	0
	CP-40298	50	0	0	0	0
		100	0	0	0	0
		200	0	0	0	0
	fenthion	50	0	13	1	0
		100	0	15	1	1
		200	1	15	1	1
	tormel[c]	10	1	1	1	
		20	1	1	1	
		100	3	3	1	
		200	6	6	1	
	Stauffer N-2101[b]	50	0	1	1	0
		100	0	11	1	0
		200	0	21	13	0
phosphoro-dithioate	dimethoate[d]	120	11	26	20	
	H-7816D[b]	50	0	0	0	0
		100	0	0	0	0
		200	0	0	0	0
	SD-7438[b]	50	0	0	0	0
		100	0	0	0	0
		200	0	0	0	0
	Stauffer N-2788[b]	50	0	1	0	0
		100	0	1	0	0
		200	0	1	0	0
	Stauffer N-2789[b]	50	0	0	0	0
		100	0	1	0	0
		200	0	1	0	0
	Stauffer N-2790[b]	50	0	0	0	0
		100	0	0	0	0
		200	1	1	0	0
carbamate	Baygon	50	0	3	0	0
		100	1	6	1	1
		200	3	6	1	3
	Bayer 37341	50	0	33	0	0
		100	1	33	0	25
		200	33	33	0	32
	H-9699	50	7	23	0	0
		100	7	35	23	0
		200	9	42	35	17
	HRS-1422	50	4	8	1	0
		100	8	21	4	8
		200	20	45	1	17
	UC-10854	50	0	1	0	0
		100	0	1	0	0
		200	0	9	0	0

[a] CSMA strain unless indicated otherwise.
[b] Roberds-45 strain (dieldrin resistant).
[c] Tested at 40, 80, 100, and 200 mg/ft² on 3 surfaces only.
[d] Tested at 120 mg/ft² on 3 surfaces only.

of the compounds is influenced by the surface material treated.

While the compounds in the phosphate and phosphorodithioate classes, except for dimethoate, were far less effective than the carbamates or phosphorothioates tested, the variability in efficacy within these classes (e.g., HRS 1122 vs. H-9699 against *B. germanica* or vs. UC 10851 against *M. domestica*) would indicate that these differences are more specific for individual compounds than characteristic of the chemical group.

The effect of surface material on the potency of the *different compounds is demonstrated in these chemi*cals that are markedly toxic to the 2 species of insects tested. On the basis of the 22 compounds, it is apparent that unpainted metal is the surface on which the deposits were effective for the greatest period, with the reverse true for painted metal. Deposits on the other surfaces, asphalt tile and masonite, persisted better than those on painted metal (except for dimethoate) but were definitely inferior to residues on unpainted metal. Exceptions to this generalization are evident, since H-9699 remained effective against both flies and cockroaches for extended periods on unpainted metal, tile, or masonite. Another illustration is the results for B-37311 whose deposits at 200 mg ft² were equally effective against flies on painted and unpainted metal surfaces. Other exceptions are Bayer 30237, naked, and dichlorvos.

The dosage applied has been indicated (Mathis and School 1963) as sometimes influencing the effect of the surface material on the persistency of residues. The data for B-37311 against *M. domestica* indicate it as highly effective on unpainted metal at 50 mg/ft² but completely impotent at that dosage on painted metal. However, at 200 mg ft² the compound showed equal efficacy on both these surfaces. With H-9699 a similar response is apparent on unpainted metal, masonite, and tile against either *M. domestica* or *B. germanica*. With other compounds (N 2401 on painted metal and tile, HRS 1122 on masonite, UC 10854), an increase in dosage did not produce any change in the efficacy of the deposit on certain surfaces.

Differences in species response also varied with the compound. Compounds effective against *M. domestica* could give a similar efficacy against *B. germanica* (e.g., H-9699), or could show a much lower degree of effectiveness (B-37311, B-31098, HRS-1122).

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Table 4.—No. of weeks of effective kills of female *B. germanica*[a] exposed for 3 hr to emulsion residues of various compounds on 4 surfaces.

Class	Compounds	Mg/ft²	Galvanized metal: Painted	Galvanized metal: Unpainted	Masonite: Unpainted	Tile: Unpainted
phosphate	dichlorvos	50	1	0	1	1
		100	1	0	1	1
		200	2	0	2	2
	naled	50	1	1	1	1
		100	2	1	2	2
		200	3	1	2	2
phosphoro-thioate	Bayer 30237	50	1	1	1	0
		100	1	2	2	1
		200	2	2	2	2
	B-31098	50	1	1	1	0
		100	1	3	3	0
		200	1	3	5	3
	B-41831	50	0	1	1	0
		100	1	1	1	0
		200	1	2	1	0
	B-10676	50	1	1	1	0
		100	1	4	4	0
		200	2	10	10	0
	CP 10294	50	0	1	0	0
		100	0	1	1	0
		200	1	3	4	0
	diazinon	50	1	1	1	1
		100	1	1	1	1
		200	2	1	2	2
	fenthion	50	0	2	1	0
		100	0	2	1	0
		200	0	11	2	0
	ronnel[b]	10	0	1	0	0
		50	0	1	1	0
		100	0	1	1	0
		200	1	1	1	0
	Stauffer N-2401	50	1	1	1	0
		100	1	6	1	0
		200	1	11	6	0
phosphoro-dithioate	Hercules 7964B	50	0	0	0	0
		100	0	0	0	0
		200	1	11	0	0
	SD 7438	50	0	0	0	0
		100	0	0	0	0
		200	0	0	0	0
	Stauffer N-2788	50	0	1	1	0
		100	0	1	1	0
		200	1	2	2	0
	N-2789	50	0	1	0	0
		100	0	1	0	0
		200	1	2	1	0
	N-2790	50	0	1	0	0
		100	1	1	1	0
		200	1	1	1	1
carbamate	[illegible]	50	3	3	[illegible]	[illegible]
		100	3	3	[illegible]	[illegible]
		200	3	3	[illegible]	[illegible]
	Bayer 37511	50	0	0	0	0
		100	0	1	0	0
		200	1	3	0	1
	H-9699	50	2	18	0	[illegible]
		100	4	22	2	[illegible]
		200	4	22	10	[illegible]
	HRS 1122	50	0	0	0	0
		100	0	0	0	0
		200	0	0	0	0
	UC 10851	50	1	2	1	0
		100	1	3	1	1
		200	2	3	5	2

[a] Chlordane-resistant (Fort Rucker strain).
[b] Tested at 10, 50, 100 and 200 mg/ft².

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